Intel Labs:
Designing the Future

intel®

Pioneering Innovation Through Advanced R&D

Imagine a world where everything from your telephone to your digital camera to your family's bulletin board was connected to the Internet. Now imagine it all being wireless, data passing effortlessly through walls and traveling thousands of miles.

What if a transistor was so small a billion fit in a chip the size of a dime? Or a processor was so fast it could complete millions of calculations in the time a bullet traveled an inch?

Think what a growing company could do with a network that sets up in minutes without a single server. Or what a PC as reliable and easy to use as a toaster could mean to you.

Pipe dreams? Hardly. New ideas and innovations such as these are the daily pursuit of Intel Labs, a network of Intel research and development professionals. Intel's R&D efforts focus on the building blocks of the worldwide Internet economy. This includes everything from the computer you use to go online, to the server that handles your transaction, to the cellular phone that displays your latest emails. Intel's extensive R&D efforts are the engine that drives the company's success and will continue to guide both Intel and the industry in the future.

Intel Labs are a decentralized federation of labs that foster innovation, not bureaucracy. Intel takes advantage of the best talent and resources wherever they can be found.

Our R&D focuses on five key areas:

- **Silicon Technology and Manufacturing.** Intel has a long history of designing and manufacturing complex silicon devices, starting with the world's first microprocessor. Today our microprocessors and other silicon devices are found in everything from the computer on your desk to the cellular phone in your hand. Our labs are working on innovations, such as EUV lithography and 15-nanometer (15 billionths of a meter) transistors that are the world's fastest, as well as cost-effective and power-efficient. These will enable us to continue to extend Moore's Law for another decade.
- **Microarchitectures and Circuits.** As heat and power consumption reach their limits on a microprocessor, the quest for greater microprocessing performance is moving into new areas. At Intel Labs, we're developing innovative schemes for organizing the various hardware elements of a chip (such as the arithmetical units, register files, data paths, and caches) to produce new ways to achieve greater performance. These innovations will soon be improving and even redefining chip performance.
- **Computing Hardware.** We're laying the groundwork for a wide range of next generation computing devices. These include servers, desktop PCs, mobile computers, handhelds, and entirely new digital devices. Tomorrow's servers may look radically different as we use disaggregation to separate storage and processing into different boxes, even different rooms, to improve scalability and make it easier to add transaction power. For the computer on your desk, we're developing a faster bus than PCI to increase the performance between your computer and its peripherals.
- **Computing Software.** A large part of our work is developing software that enhances the way our processors and other hardware products will work with next generation applications. But we also look beyond the expected. We work on new usage models, such as more natural interfaces for speech, imaging and wireless technologies. We explore new software solutions like XML-based Web Services. And we look for ways to develop software and software specifications so computers and other devices can be a lot smarter in how they anticipate and answer our needs.
- **Communications and Networking.** Today we have independent interactions with our work computers, home computers, cellular phones, PDAs, and many other electronic devices. This creates a lot of duplicated effort, especially inputting data. We're working on technologies that will enable these devices to effortlessly exchange information with each other. Our goal is a world where all your personal devices constantly share data, enabling you to get the information you need no matter which device you're using at the moment.

Intel Labs at a Glance:

- More than 7,000 scientists and technologists worldwide
- Over 75 R&D labs in nearly a dozen countries
- Academic alliances with more than 130 universities worldwide
- Advancing technology at the rate of 3 patents a day

Focusing on Real Products for Real People

At Intel Labs, we don't invent basic technologies to see if they might lead to products. We leave nothing to chance. We focus on the entire product chain. Our typical process is to:

- Pursue technologies that have a recognized product value
- Organize the necessary industrial community
- Develop the necessary specifications, standards and protocols for rapid adoption
- Create products from each technology that actually meet real human wants and needs

This process doesn't mean we don't pursue research outside our traditional focus. Quite the contrary. We have other efforts focused on "disruptive technologies" — technologies not currently supported by the roadmaps of our business units, but which may lead to new business opportunities.

Enabling Broader Research Efforts

In addition to its own in-house R&D programs, Intel sponsors more than 300 university research programs at nearly 100 universities worldwide. The company donates millions of dollars to institutions of higher education, including Caltech, Carnegie-Mellon, MIT, Stanford, and the University of California at Berkeley.

The goal of Intel-sponsored research is to build mutually beneficial relationships with university research programs. This is accomplished through:

- University research and equipment grants and gifts
- Intel forums, seminars and events for research teams
- Researchers in residence and visiting faculty collaboration at Intel
- Joint Intel/university research projects

Intel also supports relationships with over a dozen focused consortia. Examples include the Semiconductor Research Corporation (SRC), the MIT Leaders for Manufacturing, MIT Media Lab, Stanford Center for Integrated Systems, Stanford Integrated Manufacturing Association, and Georgia Institute of Technology Broadband Telecommunication Center.

Intel Research labs located at leading universities team up with faculty and student researchers to conduct research in emerging areas of computer science and information technology. The activities of the individual labs are project-focused, involving researchers from Intel, local universities, and members of the global research community.

A Look at Four Technologies in Intel R&D

EUVL(Extreme Ultraviolet Lithography)

Photolithography is a process by which light is passed through a photomask to help create microscopic circuit patterns in microprocessors. Current lithography technology will allow Intel to print circuits not much smaller than 0.1 micron in width, or 1/1,000th the width of a human hair. Extreme Ultraviolet Lithography (EUVL) is a technology breakthrough that could allow semiconductor manufacturers to print circuit lines well down to at least 0.03 microns, extending the current pace of semiconductor innovation at least through the end of this decade. Processors built using EUV technology are expected in the early part of the second half of the decade.

Multi-Threading

Adding more transistors to a microprocessor isn't the only way to increase performance. Today, as we run into problems with power consumption and heat, we're looking at new strategies for extracting greater performance from our microprocessors. One way is multi-threading, finding ways of executing multiple independent instruction strings simultaneously within a processor. It's like addressing a single processor as if it were two. This increases the percentage of processor resources used at any particular moment. Better utilization equals better performance.

Intelligent Roaming

How can a mobile computer keep you continuously connected to the Internet and available by voice and email as you move from place to place, network to network? With intelligent roaming technologies. We're working on solutions involving hardware and software that will enable you to go from one wireless service area to another, or from wired to wireless environments without missing a beat. The key is smart technology that always chooses the best connection based on quality and cost.

Ultra Wide Band (UWB)

What would a world be like where everything from your computer to your digital camera to your telephone to your family's bulletin board were connected to the Internet? All kinds of amazing new applications could be developed connecting all the people and things in your life. We're finding ways to make this happen. Like our work in Ultra Wide Band (UWB). This former radar technology could remove the wires and allow short distance communications throughout a home, allowing all your computing and digital devices to exchange low-power but extremely wide signals for fast information exchange.

Impacting the Broader Industry

Furthering Intel's impact on the industry as a whole, Intel technologists influence and participate with the industry through numerous industry forums, special interest groups (SIGs), consortia and standards bodies. This chart provides a few examples of the many organizations in which we participate.

Industry Group	Focus	Intel's Role
Digital Display Working Group (DDWG)	Enhancing the Digital Visual Interface (DVI) specification for connecting display devices such as flat panel monitors and electronic projectors to computers.	Founder
European Computing Machines Association (ECMA)	Standardizing international information and communication systems.	Member
Extreme Ultraviolet LLC, (EUV LLC)	Developing EUV-based lithography technology for manufacturing chips beginning in the early part of the second half of the decade.	Board Member
IEEE 1394 Trade Association	Overseeing the industry standard specification for high-speed serial bus.	Board Member
Moving Picture Experts Group (MPEG)	Developing the standards for video and audio technologies.	Member
Networking Processing Forum (NPF)	Encouraging the growth and effective use of network processing technology.	Co-founder
Peer-to-Peer Working Group (P2PWG)	Facilitating and accelerating best-known practices for peer-to-peer computing.	Board Member
Public Key Cryptography Standards (PKCS)	Improving computer security.	Member
Speech Application Language Tags (SALT)	Creating standards to make it easier to develop speech-enabled Web sites.	Co-founder
Third Generation Partnership Project (3GPP)	Developing and maintaining the technical specifications for the Global System for Mobile (GSM) communications.	Member
Trusted Computing Platform Alliance (TCPA)	Developing a specification at the hardware and operating system levels for an enhanced trusted computing platform.	Co-founder
USB Implementers Forum (USB-IF)	Facilitating the easy connection of cameras, scanners and other devices to PCs.	Co-founder, Chairman
World Wide Web Consortium (W3C)	Enhancing the capabilities of the Web.	Member

The Digital World of Tomorrow Is in Our Labs Today

To learn more about Intel Labs and the projects we're working on right now, visit:
www.intel.com/labs

This document and related materials and information are provided "as is" with no warranties, express or implied, including but not limited to any implied warranty of merchantability, fitness for a particular purpose, non-infringement of intellectual property rights, or any warranty otherwise arising out of any proposal, specification, or sample. Intel assumes no responsibility for any errors contained in this document and has no liabilities or obligations for any damages arising from or in connection with the use of this document. Intel and Intel Personal Internet Client Architecture are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

*Other names and brands may be claimed as the property of others.
Copyright © 2002, Intel Corporation. All rights reserved.
Printed in the USA/0102/3K/ID/CS IL-008

A History of Innovation

To understand how much impact our work at Intel Labs could have on the future, simply look at our past. Intel has created or contributed technology to many of the innovations that make computing and communications what they are today. Here are some top examples.

- MOS (Metal on Silicon) production
- Intel® 4004 microprocessor — First microprocessor
- Intel® 8008 microprocessor — First 8-bit microprocessor
- Intel® 8086 microprocessor — First 16-bit microprocessor
- Intel386™ microprocessor — First 32-bit compatible microprocessor
- Universal Serial Bus (USB)
- Peripheral Component Interconnect (PCI)
- Ethernet
- Compiler technologies
- IEEE Floating Point standard